Proposed Europa Lander Descent Stage Overview

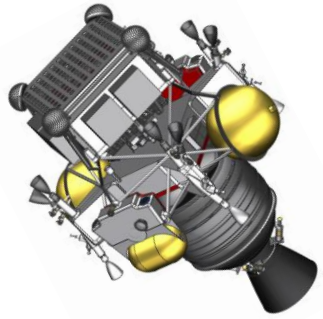
Tejas Kulkarni, Devin Kipp, Steve Sell, Aline Zimmer, David Skulsky, Miguel San Martin
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

15th International Planetary Probe Workshop
Boulder, Colorado
June 2018

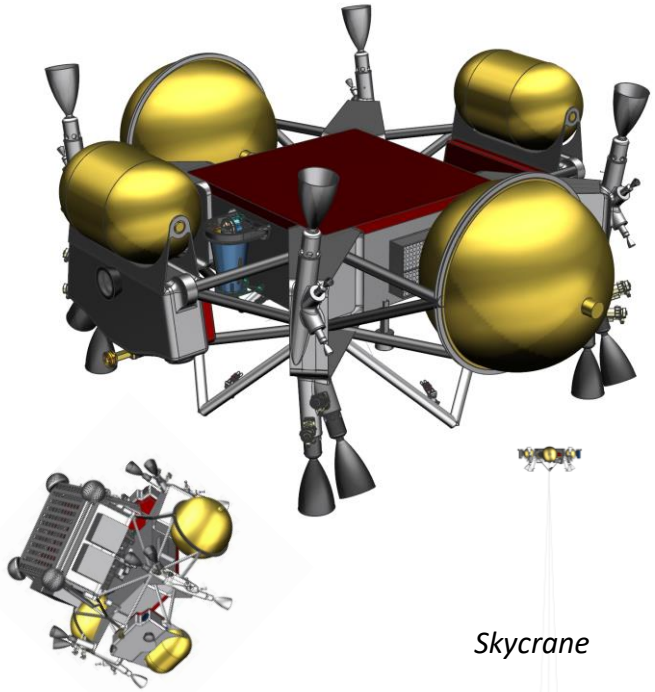
Descent Stage Concept

- The Descent Stage (DS) is conceptually the DDL functional element in the flight system
  - DS would perform all sensing, processing, and commanding from CS separation thru flyaway

- Architectural considerations:
  - 'self-contained' DDL machine
  - no science accommodation
  - tolerant to interruption
  - planetary protection
  - central location in DOV stack
  - operate in multiple configurations:
    - DOV - Coast / DeOrbit
    - PDV - Descent
    - SkyCrane - Landing
    - DS only – Flyaway

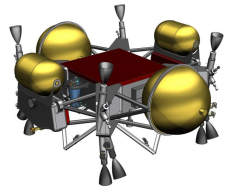


Coast



Deorbit & Descent

Skycrane

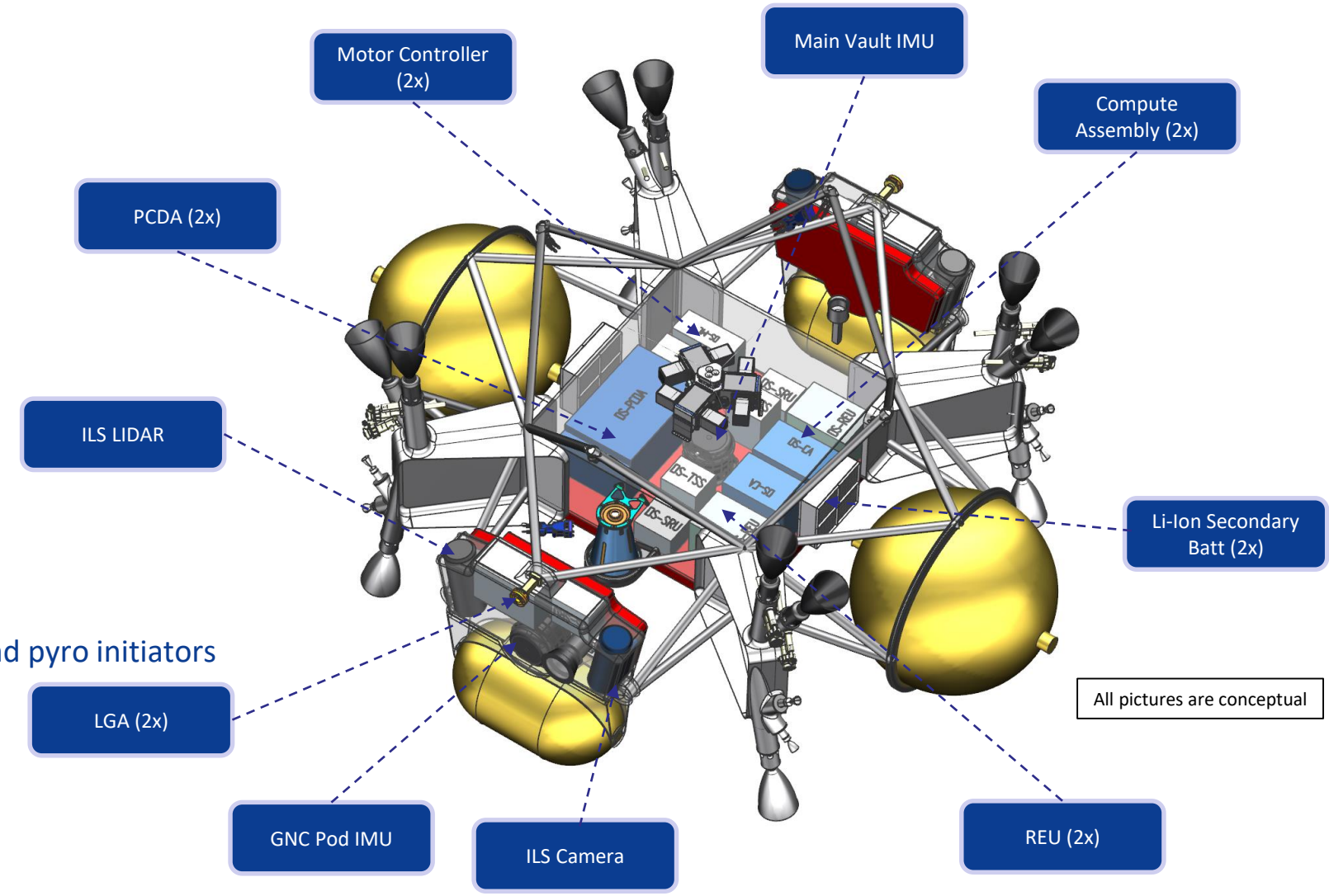


Flyaway

All pictures are conceptual

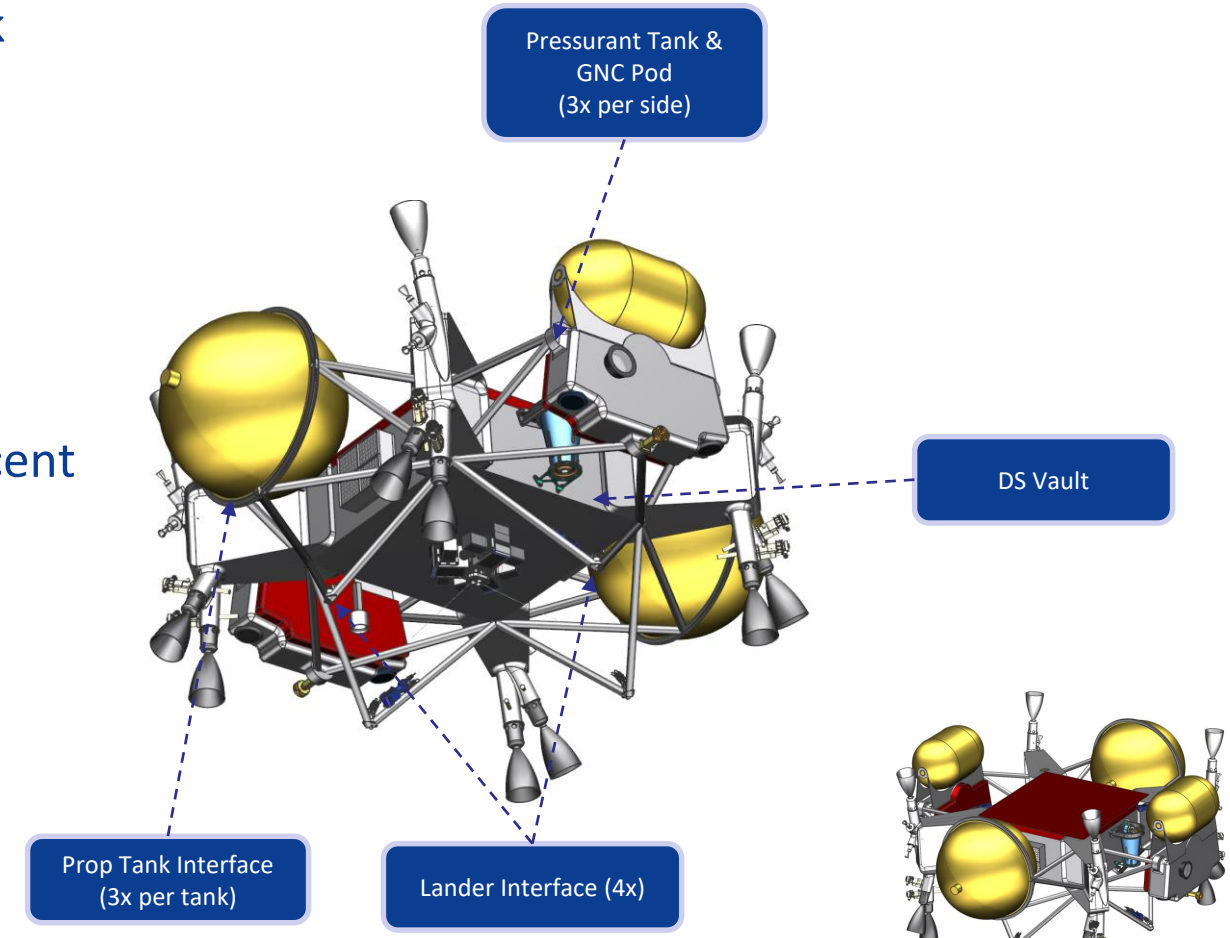
Proposed Descent Stage : the “Brains”

- Dual String Avionics:
  - DS Compute Assembly (2x)
  - DS REU (2x)
  - DS Motor Controller (2x)
  - IMU
- DDL GNC Pods (2x):
  - IMU
  - ILS Cameras
  - LIDAR
  - Star Tracker
- Power:
  - High power secondary Li-ion battery
    - Similar to Mars Helicopter
  - Power drivers are motor controller and pyro initiators
- Telecom:
  - Two LGA’s provide ~omni coverage
  - Tones only DDL Comm
  - Radio/Amp on lander (not shown)



Proposed Descent Stage: the “Bones”

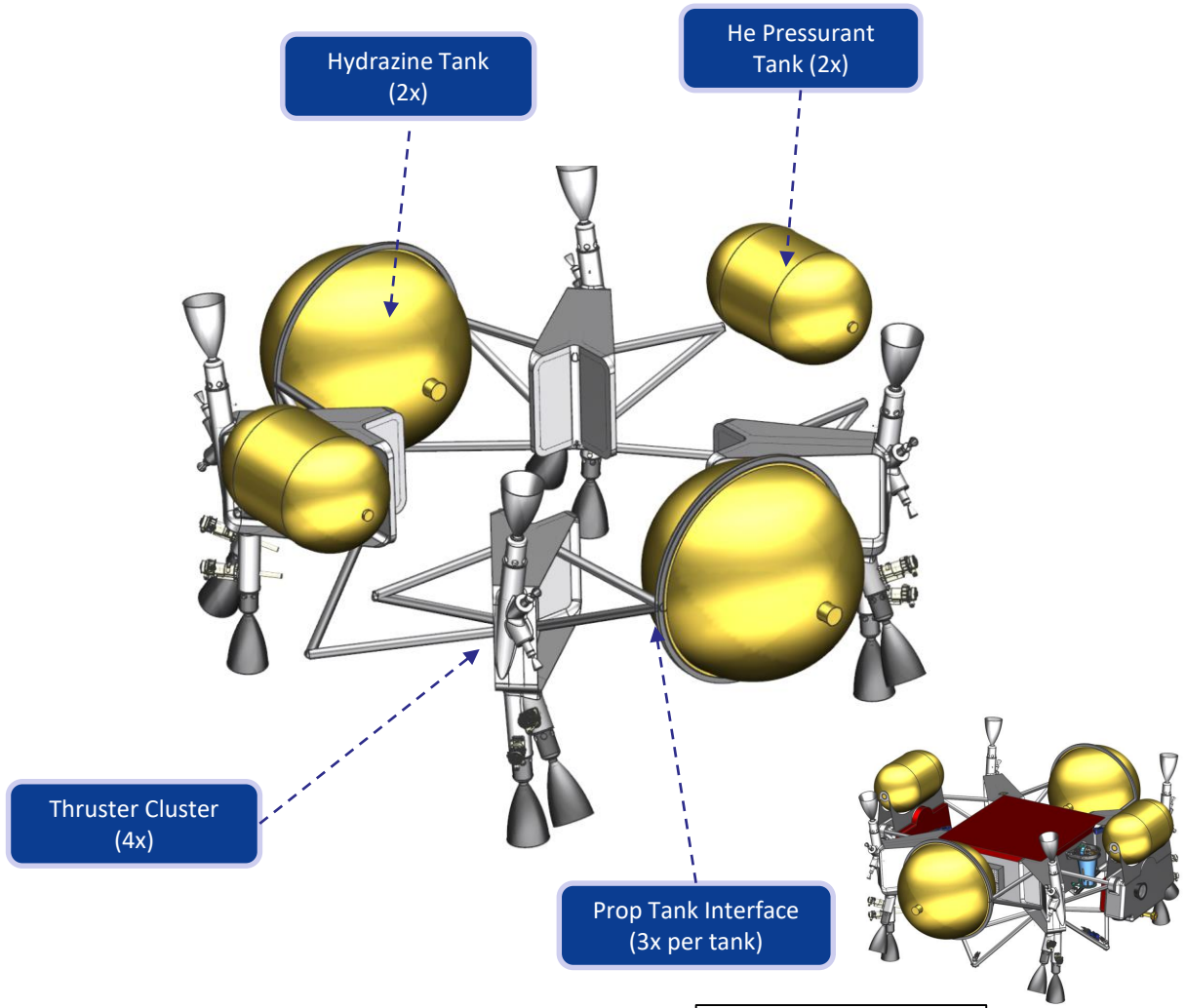
- Core structure would take advantage of thick vault walls (8.5 mm) driven by radiation environment
  - >20 hz primary structure
  - Primary load path thru DS
- Secondary structure would interface to adjacent FS assemblies and DS hardware
  - 4 point interfaces to DOS / Lander
  - Interfaces to sensors and tanks
  - >20 hz mounting stiffness



All pictures are conceptual

Proposed Descent Stage : the “Muscle”

- Propulsion sized to accommodate required T/W during DDL
- Multiple engine sets divided by function:
  - Thrust Vector Control (TVC) – 4x MR-104G (800N)
    - Used for ”periapsis drop maneuver” after separation and to manipulate SRM thrust vector
  - Descent Engines (DE) – 8x MR-104G (800N)
    - Primary engines for Powered Approach and Landing
    - MSL style throttle valves for descent engines
  - Attitude Control Thrusters (ACS) – 4x MR-106 (22N)
    - Used for attitude control primarily during Coast
- Custom propellant and helium tanks to accommodate fuel requirements



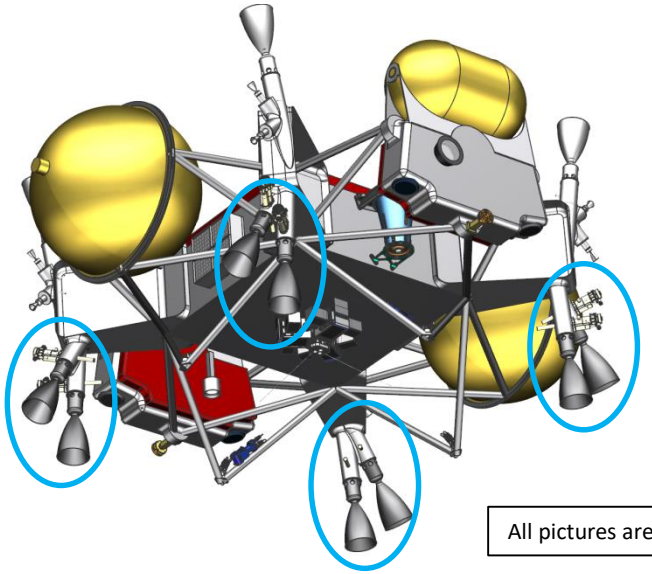
All pictures are conceptual

Proposed Descent Stage : the "Muscle"

Proposed Descent Engine (DE) configuration similar to MSL:

- 4x MR-104 engines – canted 5° (not used after lander sep)
  - Maintain High Thrust to weight through powered approach
- 4x MR-104 engines – canted 30°
  - Preserves plume-free zone along y-axis
- 800N max thrust per engine
- MSL style throttle valve adapted for MR-104s

DE Performance Drivers	Notional Requirement
T/W_{max} @ PA_{start}	>2.5
T/W_{max} @ TD_{minus}*	>1.2
T/W_{min} @ TD_{plus}*	<0.8
Att. Control @ PA_{start}	>50 $^{\circ}/s^2$
Att. Control @ SC_{start}*	>50 $^{\circ}/s^2$



All pictures are conceptual

MR-104

http://www.rocket.com/propulsion-systems/monopropellant-rockets

Proposed Descent Stage : the “Muscle”

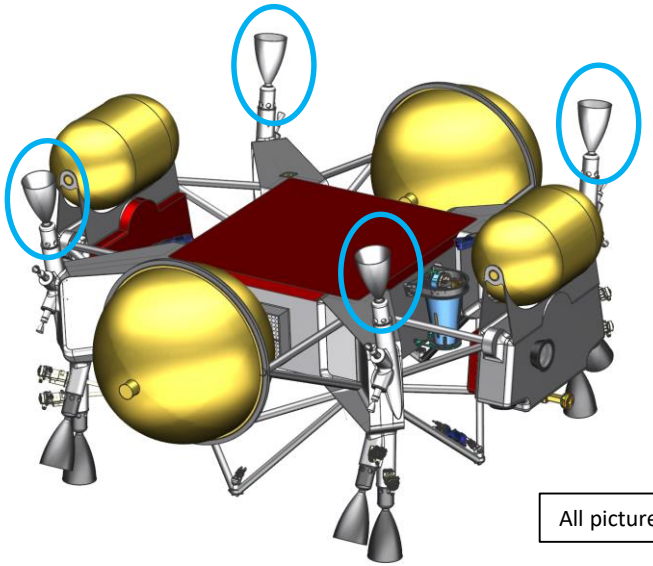
Proposed TVC Engine Configuration:

- 4x MR-104 engines
- 800N max thrust per engine
- Pulsed valve

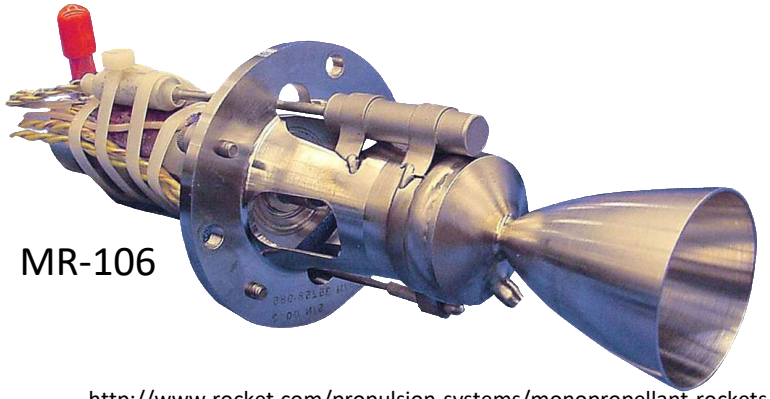
Proposed ACS Engine Configuration

- 8x MR-106 engines
- 800N max thrust per engine
- Pulsed Valve

ACS Performance Drivers	Notional Requirement
Deadbanding Fuel Consumption in Coast	< 1 kg
DOV Max Slew Duration	< 120 sec
PDV Slew Rate from Min Torque Bit^ (for imaging)	> [1] ˚/s



All pictures are conceptual



MR-106

http://www.rocket.com/propulsion-systems/monopropellant-rockets

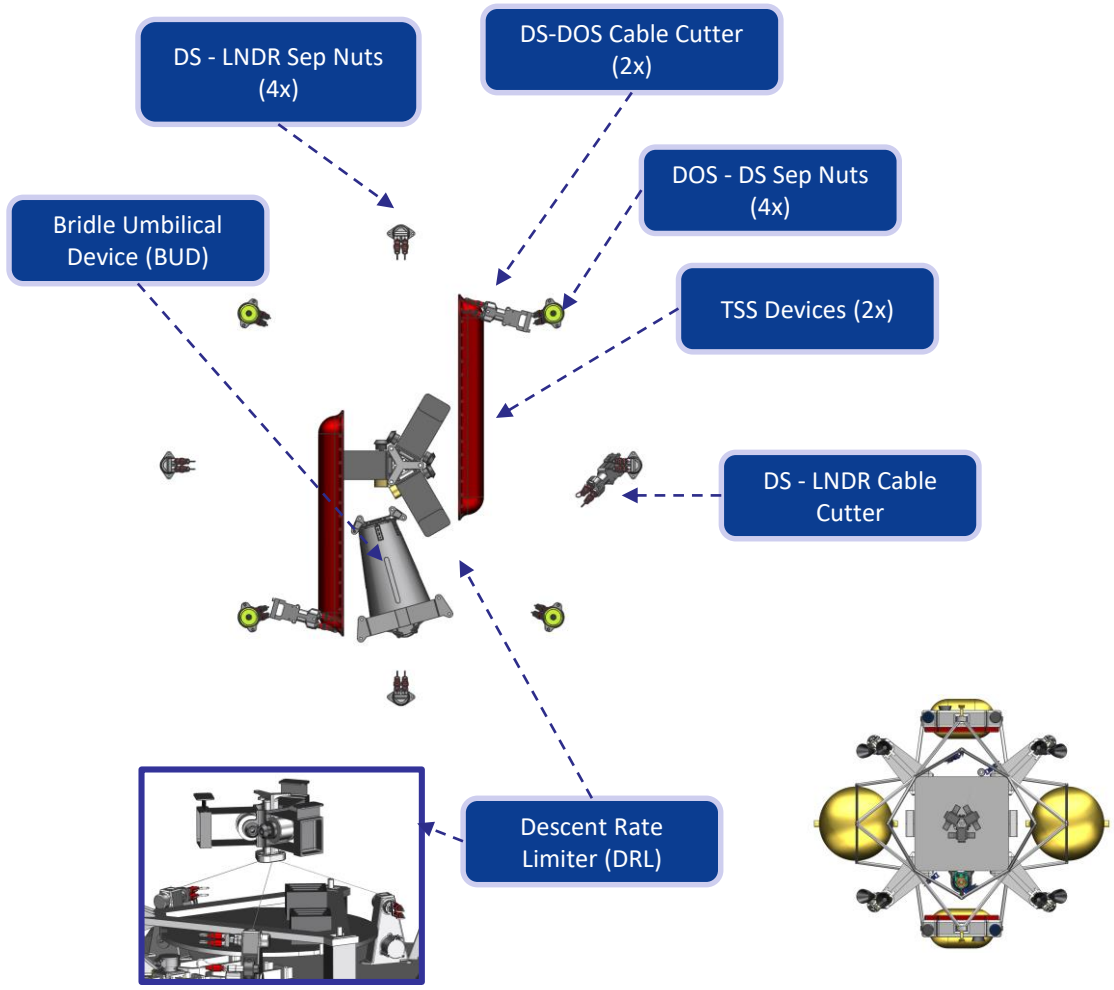
Proposed Descent Stage: mechanisms

- Separation hardware would have significant flight heritage

- DRL and BUD hardware design concepts:
  - DRL and BUD must be at least 10m long to accommodate skycrane
  - DRL concept incorporates lessons learned from MSL development

    includes 1-DOF tunable flex mount
    to ensure GNC performance in SkyCrane
  - BUD concept is copy of MSL
    - Other options are being investigated

- TSS hardware – several concepts under study:
  - Mass/volume reserved as shown
  - Maintaining flexibility to accommodate baseline once established



Backup